Solutions to selected exercises from Chapter 7

7.1

1. a. $f(2) = 2$
$g(2) = 6$
$(f + g)(2) = 2 + 6 = 8$

b. $(f \times g)(2) = 2 \times 6 = 12$

9. a.
$$f(4) = 0$$
$$g(4) = -5$$
$$(f + g)(4) = 0 + (-5) = -5$$

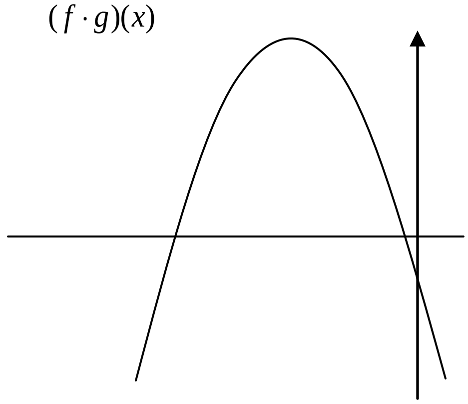
b. $(f - g)(4) = 0 - (-5) = 5$

c. $(\frac{f}{g})(4) = \frac{0}{-5} = 0$

d. $(f \cdot g)(4) = 0 \times (-5) = 0$

15.
$$f(x) = x^2 - 4$$
$$g(x) = 2x + 8$$
a.
$$\begin{aligned}(g - f)(x) &= (2x + 8) - (x^2 - 4)\\ &= 2x + 8 - x^2 + 4\\ &= -x^2 + 2x + 12\end{aligned}$$
b.
$$\begin{aligned}(\frac{f}{g})(x) &= \frac{x^2 - 4}{2x + 8}\\ &= \frac{(x + 2)(x - 2)}{2(x + 4)}\end{aligned}$$

23. $(f \cdot g)(x)$



33. The function $(\frac{C}{P})(t)$ represents the crime rate, in crimes per person, in this particular city.

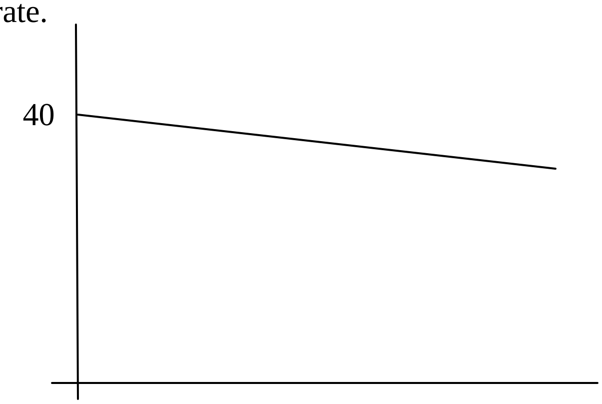
41. a. $R(S) = 1.1S$
b. $B(S) = 0.056S^2 - 0.001S + 0.021$
c.
$$\begin{aligned}(R+B)(S) &= 1.1S + 0.056S^2 - 0.001S + 0.021 \\ &= 0.056S^2 + 1.099S + 0.021\end{aligned}$$
The function $(R + B)(S)$ gives the total stopping distance including both the reaction distance and the braking distance.
d. $(R+B)(S) \approx 312.72$ A car traveling 75 MPH will need 312.7 feet to come to a complete stop once the brakes are applied.

45. a. $M(15)$ gives the mean SAT score for males in $1987 + 15 = 2002$. Note that $M(15) \approx 534$.

b. $F(15)$ gives the mean SAT score for females in $1987 + 15 = 2002$. Note that $F(15) \approx 500$.

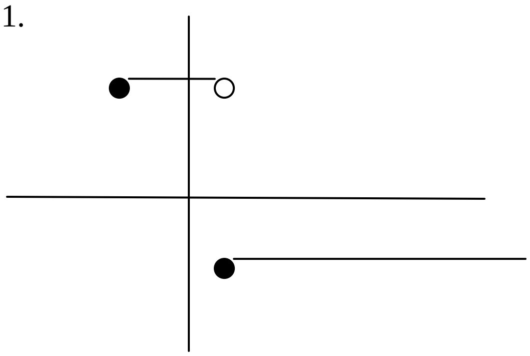
c. $(M - F)(t)$ gives the difference between male and female SAT scores for any value of t.

d. While the difference between male and female SAT scores is decreasing as t increases, the function $(M - F)(t)$ is decreasing at a relatively slow rate.

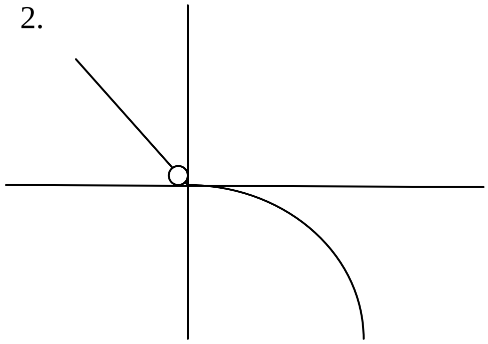


7.2

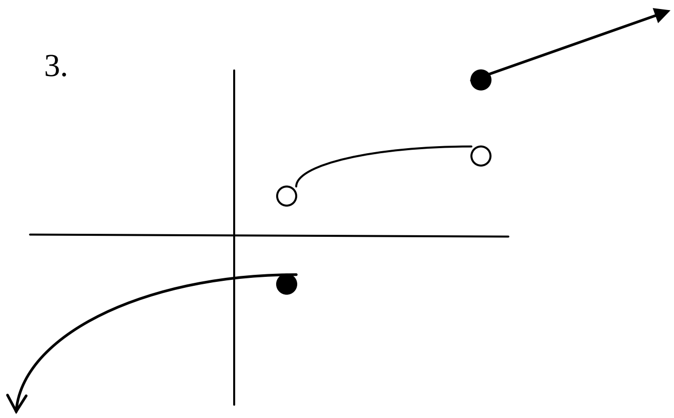
1.



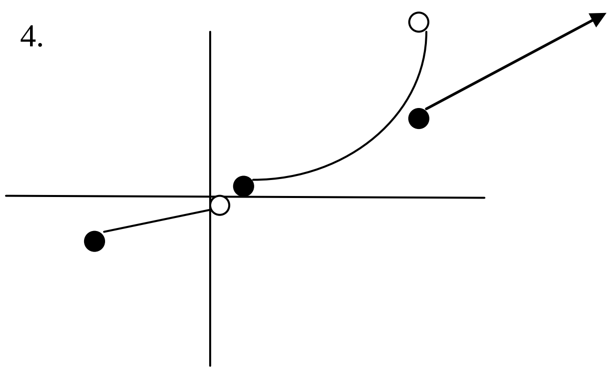
2.



3.



4.



6.

$$f(x)=\begin{cases}7 & 2<x\le 5\\ 5 & 6<x\le 9\end{cases}$$

7.

$$f(x)=\begin{cases}1+\dfrac{5}{2}x, & 0\le x\le 3\\ 13.5-\dfrac{3}{2}x, & 3<x\le 9\end{cases}$$

9.

$$f(x)=\begin{cases} x^2, & 2\le x\le 4 \\ x+2, & 4\le x<9 \\ 146.05(0.8055)^x, & 9\le x\le 14 \end{cases}$$

10. a. From 0 to 4 months.
b. Other than when they were going 0 mph, it was from 4 to 8 months.
c. 0 to 2 months.

11. a.

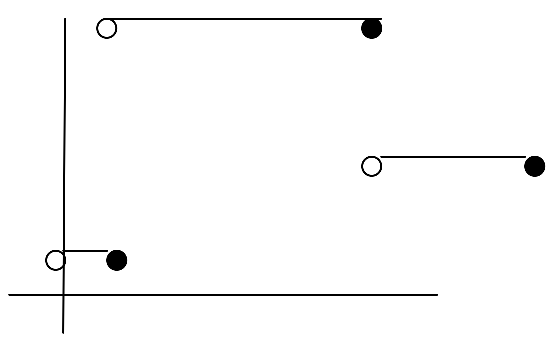
$$c(w)=\begin{cases} 0.39, & 0<w\le 1 \\ 0.63, & 1<w\le 2 \\ 0.87, & 2<w\le 3 \\ 1.11, & 3<w\le 4 \\ 1.35, & 4<w\le 5 \\ 1.59, & 5<w\le 6 \\ 1.83, & 6<w\le 7 \\ 2.07, & 7<w\le 8 \\ 2.31, & 8<w\le 9 \\ 2.55, & 9<w\le 10 \\ 2.79, & 10<w\le 11 \\ 3.03, & 11<w\le 12 \\ 3.27, & 12<w\le 13 \\ 3.27+0.24(w-13), & w>13 \end{cases}$$

b. $c(7)$ = \$1.83 If you are sending a letter that weighs 7 oz. it will cost \$1.83.
c. $c(w) = 3.99$, w = 16 oz. If the cost of sending a package is \$3.99, then the package weighed 16 oz.

12. a.

$$S=\begin{cases} 2.6, & 0< t\le 55.4 \\ 18, & 55.4< t<428.7 \\ 10, & 428.7< t\le 585.9 \end{cases}$$

b.



c. The first segment (on the left) represents the first leg of the race because the first leg was swimming and the tri-athlete was swimming at a constant rate of 2.6 MPH. At this rate she would have take 55.4 minutes to complete the swimming leg of the race. The second segment is the second leg of the race which was cycling since the tri-athlete cycles at a constant rate of 18 MPH. At this rate, she would take 373.3 minutes to complete the cycling leg of the race. The third leg is running since the tri-athlete ran at a constant rate of 10 MPH. AT this rate, she would take 157.2 minutes to complete that leg of the race for a total of 585.9 minutes to complete the entire race.

13. a.

$$E(k)=\begin{cases}0.058k, & 0< k\le 500\\ 0.10k, & k>500\end{cases}$$

b. $E(450)=0.058(450)=\$26.10$

c.

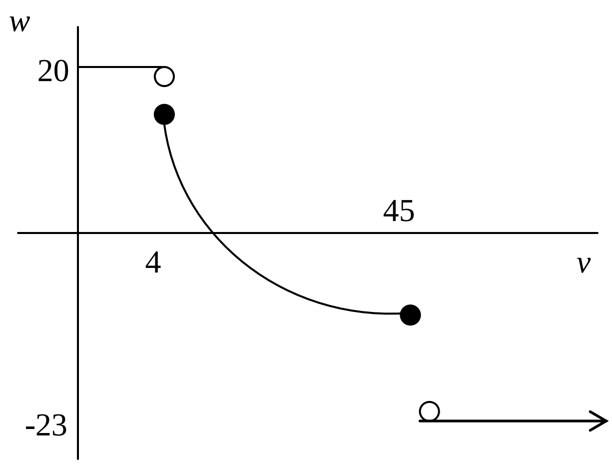
$$E(k)=\begin{cases}0.058k, & 0< k\le 500\\ 0.083k, & k>500\end{cases}$$

d. $E(450)=0.058(450)=\$26.10$

14. a. When it is 32 degrees Fahrenheit and 25 mph winds the wind chill is 18.69 degrees.

b. The function that must be graphed is

$$W(20,v)=\begin{cases}20, & 0\le v<4\\ 48.17-27.2v^{0.16}, & 4\le v\le 45\\ -23, & v>45\end{cases}$$



c. About 65 mph

$$-5 = 35.74 + 0.6215(20) - 35.75v^{0.16} + 0.4275(20)v^{0.16}$$
$$-5 = 35.74 + 12.43 - 35.75v^{0.16} + 8.55v^{0.16}$$
$$-5 = 35.74 + 12.43 - 27.2v^{0.16}$$
$$-53.17 = -27.2v^{0.16}$$
$$1.95 \approx v^{0.16}$$
$$\sqrt[0.16]{1.95} \approx v$$
$$65 \approx v$$

d. $0 \le v < 4$ because W = t at those wind velocities.

15 a.

$$T(i) = \begin{cases} 0.10i, \ 0 \le i \le 7550 \\ 755 + 0.15(i - 7550), \ 7550 < i \le 30650 \\ 4220 + 0.25(i - 30650), \ 30650 < i \le 74200 \\ 15107.50 + 0.28(i - 74200), \ 74200 < i \le 154800 \\ 37675.50 + 0.33(i - 154800), \ 154800 < i \le 336550 \\ 97653 + 0.35(i - 336550), \ i > 336550 \end{cases}$$

b.

$$0.10(2400) = 240$$
$$755 + 0.15(29700 - 7550) = 4077.50$$
$$4220 + 0.25(59300 - 30650) = 11382.50$$
$$15107.50 + 0.28(12900 - 74200) = 30451.50$$
$$37675.50 + 0.33(345000 - 154800) = 100441.50$$

c. Answers vary.

16 a.

Size	Cost
1	19.95
2	39.90
3	59.85
4	79.80
5	99.75
6	119.70
7	139.65
8	159.60
9	179.55
10	199.50

11	219.45
12	231.40
13	259.35
14	279.30
15	217.50
16	232.00
17	246.50
18	261.00
19	275.50
20	290.00

b.

$$a(n) = \begin{cases} 19.95n, & \text{n} < 15 \\ 14.50n, & \text{n} \geq 15 \end{cases}$$

c. 14 individuals will be \$279.30 a group of 15 people is \$217.50

d. A group of 19 at a cost of \$275.50.

17. a.

$$W(a) = \begin{cases} 0, & a < 2 \\ 3.99, & 3 \leq a \leq 6 \\ 4.99, & 7 \leq a \leq 12 \\ 6.99, & 13 < a \leq 65 \\ 5.99, & a \geq 65 \end{cases}$$

b. $W(3) = 3.99$
$W(6) = 3.99$
$W(9) = 4.99$
$W(24) = 6.99$
Total cost is \$19.96

c. Evaluating $W(2)$ is a challenge since the table tells us that "children UNDER 2" free. What about children that ARE 2? It is assumed that they meant to say that children that are 2 and under are free.

d. \$6.99 + \$6.99 + \$0 + \$0 + \$3.99 + \$4.99 + \$4.99 = \$30.95

18 a.

$$H(a) = \begin{cases} 129, & 3 \leq a < 10 \\ 159, & a \geq 10 \end{cases}$$

b. Domain is $a \geq 3$ and Range is $129, 159$

c.

$$A(d)=\begin{cases}83, & d=1\\ 122, & d=2\\ 159, & d=3\\ 179, & d=4\\ 189, & d=5\end{cases}$$

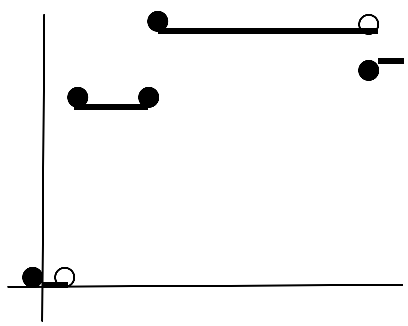
d. Domain is $1,2,3,4,5$ and Rang is $83,122,159,179,189$

e. Assuming one free child: $129(3)+159(3)=\$864$

20. a. 15 × 6 + 7 × 9.50 + 2 × 9.50 +1× 9.50 = $185

b. It is not possible because the table only give prices for party’s of 20 or more. We don’t know the regular cost for a 16 year old.

c.



d.

$$P(a)=\begin{cases}0.00, & 0<a<3\\ 6.00, & 3\le a\le 11\\ 9.50, & 12\le a\le 65\\ 8.00, & a\ge 65\end{cases}$$

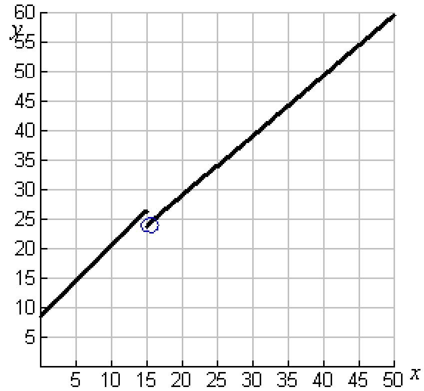
23 a.

t	*C*
0	8.50
5	14.50
10	20.50
15	26.50
20	28.90
25	34.00
30	39.10
35	44.20
40	49.30
45	54.40
50	59.50

b.

$$C(t)=\begin{cases}8.50+1.20t, & 0\le t\le 15\\ 8.50+1.02t, & t>15\end{cases}$$

c.

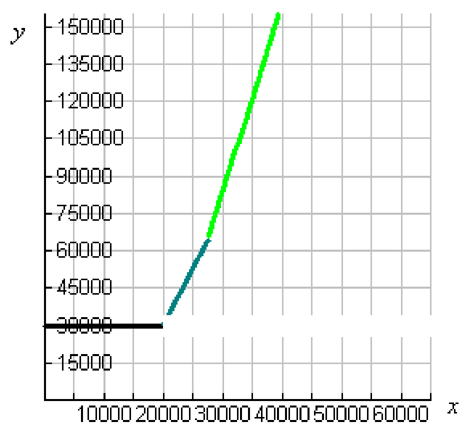


d. $86.02

24. a.

$$P(b)=\begin{cases}30000, & \text{c}\le 20000\\ 30000+0.13(35(b-20000), 20000<b\le 27500\\ 30000+34125+0.22(35(b-27500), b>275000\end{cases}$$

b.



c.

$$30000+34125+0.22(35(42556-27500))=\$180,056.20$$

d.

$$\begin{aligned}42556 &= 30000 + 0.13(35(b-20000))\\ 42556 &= 30000 + 4.55(b-20000)\\ 12556 &= 4.55(b-20000)\\ 2759 &= b-20000\\ 22759 &= b\end{aligned}$$

7.3

1.

$$f(g(t)) = 3(5-4t)^2 - (5-4t) + 4$$
$$f(g(2)) = 34$$

2.

$$f(g(t)) = f(2t^2) = 3e^{2t^2}$$
$$f(g(2)) = 3e^{2(2)^2} = 3e^8$$

3.

$$f(g(t)) = \frac{5}{1+4(2^{-0.4t})}$$
$$f(g(2)) \approx 1.52$$

4.

$$f(g(t)) = \sqrt{8(\left|3t^3\right| - t)^2 + 8(\left|3t^3\right| - t) - 1}$$
$$f(g(2)) = \sqrt{4047}$$

5.

$$\begin{aligned}f(g(t)) &= f(t^2 - 3t + 6)\\ &= 5(t^2 - 3t + 6) - 4\\ &= 5t^2 - 15t + 26\end{aligned}$$
$$f(g(2)) = 5(2)^2 - 15(2) + 26 = 16$$

6.

$$f(g(t)) = f(t-5) = \sqrt[3]{t-5}$$
$$f(g(2)) = \sqrt[3]{2-5} = \sqrt[3]{-3}$$

7.

$$f(g(t)) = 3(t^2 + 2) + 2$$
$$f(g(2)) = 20$$

8.

$$f(g(t)) = 6(t^2 - 2t - 6) + 3$$
$$f(g(2)) = -33$$

9.

$$f(g(t)) = f(\frac{1}{t}) = \frac{4}{1-5(\frac{1}{t})} = \frac{4}{1-\frac{5}{t}} = \frac{4t}{t-5}$$
$$f(g(2)) = -\frac{8}{3}$$

10. Not possible.

11.

$$f(g(t)) = f(\frac{5}{4}t) = \frac{4}{5}(\frac{5}{4}t) = t$$
$$f(g(2)) = 2$$

12.

$$f(g(t)) = (t+1)^3 - 4(t+1)^2 + 2(t+1) - 3$$
$$f(g(2)) = -6$$

14.

$$h(x) = (2x-2)^5$$
$$g(x) = 2x - 2$$
$$f(g) = g^5$$

15.

$$h(x) = \sqrt[3]{x^2 - 7}$$
$$g(x) = x^2 - 7$$
$$f(g) = \sqrt[3]{g}$$

16.

$$h(x) = \frac{1}{(x-2)^6}$$
$$g(x) = x - 2$$
$$f(g) = \frac{1}{g^6}$$

17.
$$h(x) = \left|3x^2 - 9\right|$$
$$g(x) = 3x^2 - 9$$
$$f(g) = \left|g\right|$$

18.
$$h(x) = \left(\frac{2 - x^3}{2 + x^3}\right)^2$$
$$g(x) = \frac{2 - x^3}{2 + x^3}$$
$$f(g) = g^2$$

22.
$$h(x) = (x - 1)^{\heartsuit}$$
$$g(x) = x - 1$$
$$f(g) = g\ \heartsuit$$

23.
$$h(x) = \sqrt[\Uparrow]{x^{\oplus} - x}$$
$$g(x) = x^{\oplus} - x$$
$$f(g) = \sqrt[\Uparrow]{g}$$

24.
$$h(x) = \left(\frac{4}{x \lozenge 5}\right)^{©}$$
$$g(x) = (g)©$$
$$f(g) = \frac{4}{x \lozenge 5}$$

25.
$$h(x) = \left|4x \int 9\right|$$
$$g(x) = 4x \int 9$$
$$f(g) = \left|g\right|$$

28. $D(p(l))$. With an input of l computers, the output is the revenue in dollars for l computers.

29. $l(s(h))$. With an input of h hours, the output is the profit generated from lemonade sales.

30. h(r(y)); input: year, output: number of new homes

31. c(s(w)); input: weeks, output: number of calories consumed

33. a. ≈ 2.8

b. ≈ -2.4

c. $\approx 0 + 0.2$
≈ 0.2

d. ≈ -2.8

e. $\approx -3.1, 0, 3.1$

34. a. $f(g(2)) = 4.5$

b. $f(g(1)) = 0.5$

c. $f(f(-0.5)) = 8$

d. $g(g(3)) \approx 2.7$

e. $g^{-1}(f(1.5)) \approx g^{-1}(6) = -0.25$

f. $f^{-1} \approx (f(3)) = f^{-1}(5) = 3$ or 1.5. Note that this is not a function.

37. a. $f(g(x)) = (\frac{2}{x+3})^2 - 2$

b. $g(f(x)) = \frac{2}{(x^2-2)+3}$

c. $f(h(x)) = (\sqrt{x})^2 - 2$
$= x - 2$

d. $h(f(x)) = \sqrt{x^2 - 2}$

e. $h(h(x)) = \sqrt{\sqrt{x}}$

39. $f(f(3)) = f(7) = 45$

40. a. $F(C(23)) = F(-5) = 23$

b. $C(F(5)) = C(41) = 5$

c. $F(0) = 32$

41. a. $k(c(f)) = \frac{5}{9}(f - 32) + 273$

b. Input: Fahrenheit   Output: Kelvin

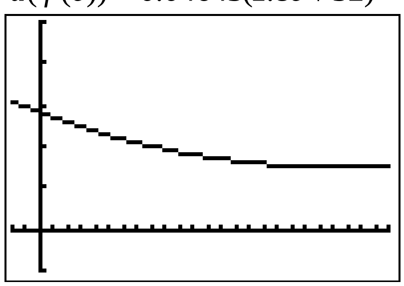
c. A temperature of 81 degrees Fahrenheit is equal to 300.2 degrees Kelvin

d.

$$572 = \frac{5}{9}(f - 32) + 273$$
$$299 = \frac{5}{9}(f - 32)$$
$$538.2 = f - 32$$
$$570.2 = f$$

A Kelvin temperature of 572 degrees is equal to 570.2 degrees Fahrenheit.

42. a. $a(f(c)) = 0.04643(1.8c + 32)^2 - 6.464(1.8c + 32) + 299.9$



b. *f(c)* is linear (has a constant rate of change) and *a(f)* is quadratic (is increasing, concave up), *a(f(c))* is quadratic (decreasing, concave up).

c.

$$f(35) = 95$$
$$a(f(35)) = 105$$
$$a(95) = 105$$

45. a.

$$\begin{aligned} J(A(K(E(U)))) &= J(A(K(U+30))) \\ &= J(A(U+30-28)) \\ &= J(U+30-28+2) \\ &= U+30-28+2-1 \\ &= U-3 \end{aligned}$$

If we know the dress size, U, in the Unites States, we can determine the dress size, J, in Japan by subtracting 3 from the dress size in the United States.

b. $J(A(K(E(10)))) = 10 - 3 = 7$. A dress size of 10 in the United States would be a dress size of 7 in Japan.

c.

$$\begin{aligned} J(A(K(E(U)))) &= 17 \\ U-3 &= 17 \\ U &= 20 \end{aligned}$$

A dress size of 17 in Japan is equivalent to a dress size of 20 in the United States.

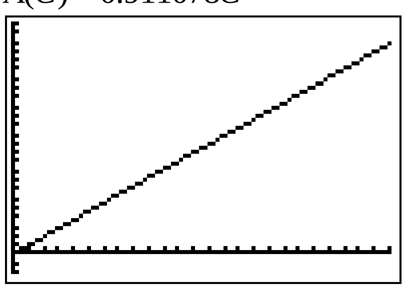
46. It is d because:

$$\begin{aligned} A(r) &= \pi r^2 \\ r(s) &= 4s \\ A(r(s)) &= \pi(4s)^2 \\ &= 16\pi s^2 \end{aligned}$$

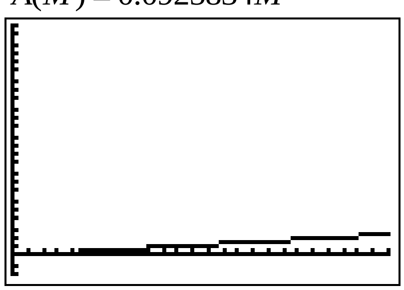
48. a.

$$A^{-1}(C) = \frac{A}{0.911078} = C(A); C(A(M)) = \frac{0.0925834M}{0.911078}$$

b. $A(C) = 0.911078C$



$A(M) = 0.0925834M$



c. Input: Canadian dollars, Output: Mexican pesos

C	***M(C)***
10	0.84
11	0.93
12	1.11
13	1.20
14	1.30

50. a. $n(m) = m - 2$
b. $p(n) = 0.95n$
c. $p(n(52)) = p(50) = 47.5$
If 52 batches of muffins are baked, 47.5 of these batches will be packaged for delivery.

53. a. $n(4)$ = \$842.904 and $s(842.904) = 28955.303$
b. In 1999 the average annual earnings of an employee was \$28,955.30.
c. s(n(3)) = \$28,408.51

7.4

1. Answers will vary. This is a sample.

x	***y***
10	100
11	98
12	90
13	80
14	60
15	50
16	45
17	42
18	41

2. Answers will vary. This is a sample.

x	***y***
0	5
1	6.2
2	7.3
3	8.2
4	8.8
5	9.2
6	9.5
7	9.7
8	9.8
9	9.9
10	9.9

3. The limiting value is $P \approx 10$ which means that profits are leveling off as the years increase towards year 4. The inflection point is approximately (2,6). The profits are beginning to increase at a decreasing rate at year 2 (2009). The company may want to release the upgraded product in approximately year 3 because profits are beginning to level off then.

4. On [0,2], the y -values decrease relatively slowly. On [3,5], the y -values decrease more rapidly. Finally, on [6,8], the y -values decrease more slowly. This type of behavior is characteristic of a decreasing logistic function.

5. 12

6. 113

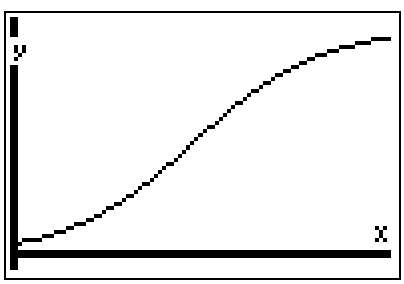
9. logistic

10. None. Appears to be a polynomial.

11. Logistic

12. None. It is not linear because it does not have a constant rate of change. It is not exponential because it does not decay or grow at a constant percentage rate. It is not logistic because it does not form the S-shaped curve.

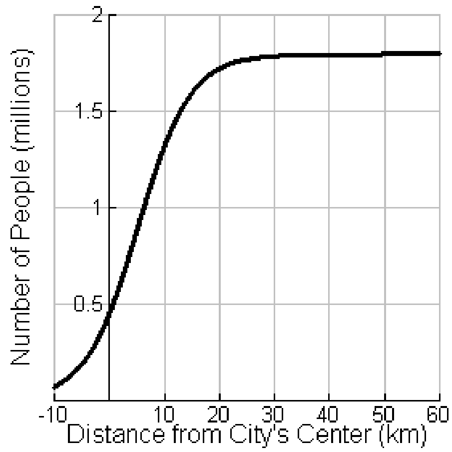
13 a.



b. Domain: $0,130$ and Range: $0,96$ Even with an unlimited number of growing days, the corn plant will not get taller than 96 inches.

c. (60, 45). This means that after 60 days of growing the corn plant is 45 inches tall and will continue to grow but at a slower pace.

14. a. The graph shows that the number of people living r kilometers from the center of the city reaches a limiting value of 1.796 million people. We can say that the approximate number of people living in Sydney is therefore 1.796 million.



b. Answers will vary. The intent is for students to choose a value of *r* just before the population reaches its limiting value. We will say that this occurs when $r \approx 24$ km.

c. The most densely populated neighborhoods can be found where the population is changing at the greatest rate. This occurs when $r \approx 5$ km.

15. Answers vary. This is a sample.

Year	***Value of stock (in $)***
2004	**22.00**
2005	23.00
2006	29.00
2007	37.00
2008	**50.00**
2009	60.00
2010	68.00
2011	74.00
2012	78.00

16. Answers will vary. While the model $T(y) = 2300(2)^y$ does not accurately represent the situation, it does not appear that the logistic model would model it well either. The relationship seems to be exponential and a regression model suggests a growth factor of approximately 1.4 (40% growth) rather than doubling.

17. a. Initially, the rate of change is relatively small which means that the rumor is spreading relatively slowly. As time increases, the rate of change increases. This means that the rumor is spreading at a faster rate. The rate then decreases and eventually gets close to zero. This tells us that the rumor spreads at a slower and slower rate until it nearly stops spreading.

b. The inflection point occurs at approximately $(17,10.9)$. This means that 17 days after the rumor began, about 11 people have hard the rumor.

c. $\frac{P(25)-P(5)}{25-5}=\frac{129.69}{20}\approx 6.5$. Between the 5th and 25th days, the rate at which the rumor spread was as if it spread at a constant rate of 6.5 people per day.

d. The limiting value appears to be 145 people. This means that there are 145 in the population who can potentially hear the rumor. No more than 145 people can hear the rumor.

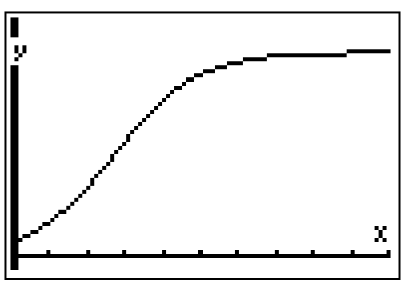
18 a. As time increases the number of stay-at-home moms is increasing at an increasing rate and then increasing at a decreasing rate until leveling off.

b. (3, 5180). In year 3 (2002) the number of stay-at-home moms is 5180 and the rate of increase in stay-at-home moms begins to slow after 2002.

c. (3, 5180) and (7, 5637) so $\frac{5637-5180}{7-3}=\frac{457}{4}\approx 114.25$. The number of stay-at-home moms is increasing by 114 each year on average from 2002 to 2006.

d. There are two limiting values. 4700 is the beginning number of stay-at-home moms and according to the model would be that number regardless of how far back into the past one goes. The other is 5648 which means that as the number of years increase indefinitely there would be 5648 stay-at-home moms.

20 a. Using the practical domain of 10 years:



b. Yes. There will be some point when the percentage of schools with internet access will become stable.

c. Using (5.9, 75.74) and (6, 76.54) the rate that the percentage of public schools with internet access was changing in 2000 is approximately $\frac{76.54-75.74}{6-5.9}=\frac{8\%}{1\text{ year}}$.

21. a. The rate at which the number of women with Ph.D.'s increases until about 1980 at which time the rate decreases. This also means that the number of women with Ph.D.'s always increases, first at an increasing rate then at a decreasing rate.

b. Answers will vary. Using the rate of change between 1950-1960 of 42 women with Ph.D.'s per year, the number will be 1000 in about 1959.

c. No.

d. It appears that the data are increasing and concave up on [0,80]. This means that the number of women with Ph.D.'s is increasing at an ever increasing rate on this interval.

e. It appears that the data is increasing and concave down on (80,99). This means that the number of women with Ph.D.'s is still increasing, but by less and less each year.

f. The point of inflection is about (80,9408). In 1980, there were 9408 Ph.D.'s awarded to women. After this point, the number of Ph.D.'s awarded to women continues to increase, but at a slower and slower rate. In terms of the historical events that may effect the number of Ph.D.'s awarded to women, answers will vary.

22 a. From 1997 to 2003 the price of VCRs decreased at an increasing rate as the sales of DVD players increased at an increasing rate. VCRs were becoming cheaper because fewer people were buying them because they were buying DVD players instead.

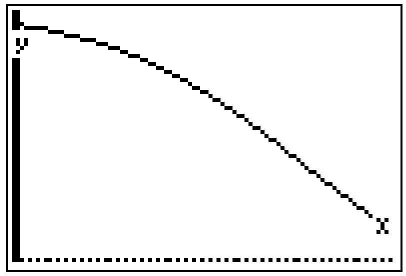
b. VCRs decreasing at an increasing rate as DVD players become more and more popular and then decreases at a decreasing rate until it reaches a limiting value of about $60 because they are not going to drop to be free. Sales of DVD players increase at an increasing rate when the first come out and then increase at a decreasing rate as the market becomes saturated and then reaches a limiting value of about 35,000,000 sales.

26 a.

$$\begin{aligned} P(8) &= \frac{919.9}{1+0.0533e^{0.07758(8)}}+90 \\ &= 926.9 \end{aligned}$$

b. (7, 932.59) and (8, 926.9) so $\frac{926.9-932.59}{8-7}=\frac{-5.69 \text{ AIDS cases}}{1 \text{ year}}$

c.



According to the rate of change in 2000 (-5.69 cases/year) and the graph showing the number of cases decreasing, it appears that the efforts to reduce pediatric AIDS is generating positive results.

7.5

1. Linear – note that for every increase in *x* of 2, *y* increases by 4.

x	*y*	First Difference
0	0	
2	4	4
4	8	4
6	12	4
8	16	4
10	20	4
12	24	4
14	28	4

Quadratic – note that for every increase in *x* of 2, the first differences increases by 8.

x	*y*	First Difference	Second Difference
0	0		
2	4	4	
4	16	12	8
6	36	20	8
8	64	28	8
10	100	36	8
12	144	44	8
14	196	52	8

Cubic - note that for every increase in *x* of 2, the second differences increases by 48.

x	*y*	First Difference	Second Difference	Third Difference
0	0			
2	-16	-16		
4	8	24	40	
6	120	112	88	48
8	368	248	136	48

10	800	432	184	48
12	1464	664	232	48
14	2408	944	280	48

Exponential – note that for every increase in *x* of 1, the consecutive ratio is always 2.

x	*y*	Consecutive Ratio
0	1	
1	2	2
2	4	2
3	8	2
4	16	2
5	32	2
6	64	2
7	128	2

2. Without scales on the axes, there is not enough information to tell. Over a small interval, the graph shown could be any of the three types of functions, depending on specific values that would be indicated by the scale.

3. D. Saying \$5 every 2 years is equivalent to saying $\$\frac{5}{2}\ (\$2.50)$ per year. The statement given in II, "…by a factor of…" implies multiplicative growth which is exponential, not linear.

4. Logistic because as the years increase the cases of chicken pox decreases at an increasing rate and then decreases at a decreasing rate.

5. Logistic because as the years increase the number of hospitals decreases at an increasing rate and then decreases at a decreasing rate.

6. Quadratic or exponential because $p(t)$ is increasing, concave up. If Quadratic, then $\begin{aligned} p(t) &= 2.075t^2 + 19273t + 629.290 \\ p(18) &= 1648.50 \end{aligned}$. If exponential, then $\begin{aligned} p(t) &= 613.831(1.054^t) \\ p(18) &= 1581.90 \end{aligned}$.

7. If we try a cubic function model, we get a good model. However, the sharp decrease after $t = 6$ gives a predication for $t = 12$ such that $B < 0$ which does not make sense. If we try a piecewise quadratic model and focus on the model for $t \geq 3$, we again get a good model. However, this model makes a prediction for $t = 12$ such that $B < 0$ also. Therefore, we choose to create a linear model using the final 2 data points.

$$\begin{aligned} B(t) &= -31t + 1121 \\ B(12) &= -31(12) + 1121 \\ &= 749 \end{aligned}$$

This prediction tells us that in 2010, the model predicts 729 non-business Chapter 11 bankruptcies.

8. Answers may vary. Assuming that the cost per credit will continue to increase and not approach a limiting value, an exponential model is used.

$$\begin{aligned} C(t) &= 35.14t \cdot (1.065)^t \\ C(12) &= 35.14 \cdot (1.065)^{12} \\ &\approx 75 \end{aligned}$$

The model predicts that the cost per credit will be about $75 for the 2010-2011 academic year.

9. The number of DVD players sold is decreasing as the price increases and most likely the number of DVD players sold will not begin to increase as the price of a DVD player increase. This means that exponential is probably the best choice for a mathematical model.

$$\begin{aligned} D(p) &= 77113.769(0.989^p) \\ D(100) &= 25{,}512{,}974 \end{aligned}$$

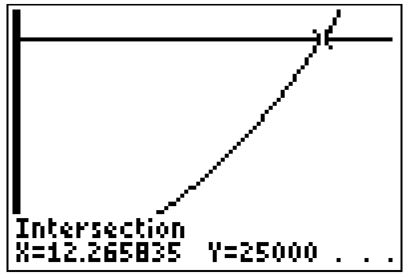
10. The average brand drug price is increasing at an increasing rate and is best modeled by a quadratic function. $\begin{aligned} D(t) &= 0.289t^2 + 3.345t + 40.972 \\ p(15) &= \$156.17 \end{aligned}$

11. Although the function values, tuition and fees, increase at a varying rate, they don’t vary much. The increase overall is relatively constant so a linear function can be used to model the data. $\begin{aligned} F(t) &= 69.610t + 534.08 \\ F(24) &= \$2204.72 \end{aligned}$

12. This function is logistic but we need to align the data by subtracting 12,000 from the golf facilities data. We then create a scatterplot and do logistic regression to get $g(t) = \dfrac{4633.08}{1 + 59.97e^{-0.26t}} + 12{,}000$. We then forecast that $g(28) \approx 16{,}449$ golf facilities.

20. Quadratic because the data is increasing at an increasing rate and it fits better than an exponential function does. The quadratic of best fit is $R(t) = 115.19t^2 - 76.31t + 8605.59$. We can determine when the radio advertising exceeds $25 billion by solving $R(t) = 25{,}000$ by using the

quadratic formula, graphing, or creating a table. Solving by graphing:



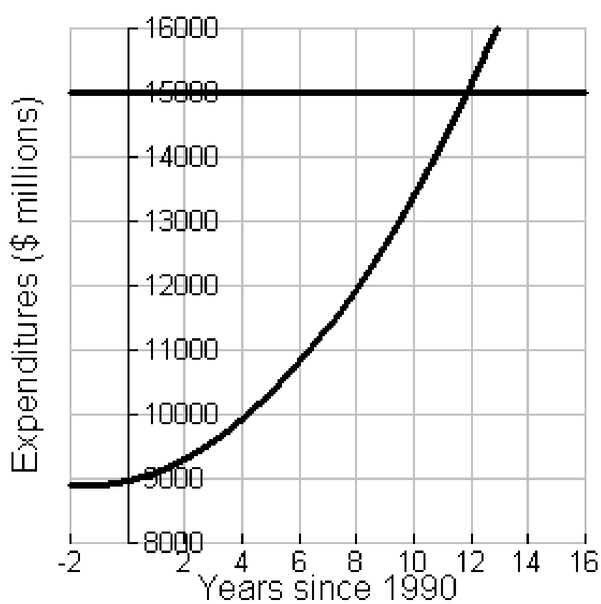
In about 2002 (year 12) there will be $25,000,000,000 in radio advertising so in 2003 we could assume that radio advertising would exceed $25 billion.

21. A quadratic model fits the data very well.

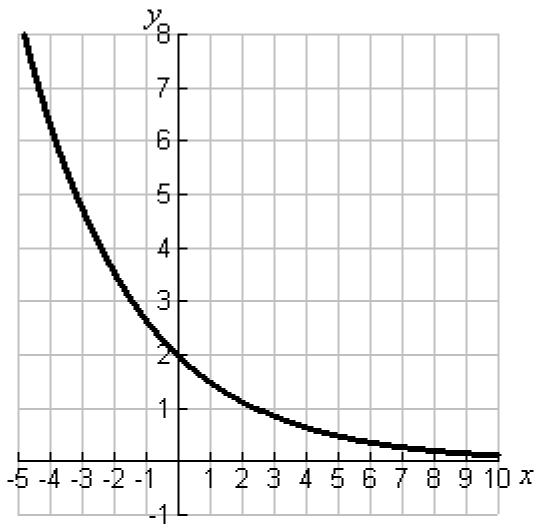
$$Y(t) = 34.99t^2 + 94.91t + 8963$$

$$15000 = 34.99t^2 + 94.91t + 8963$$

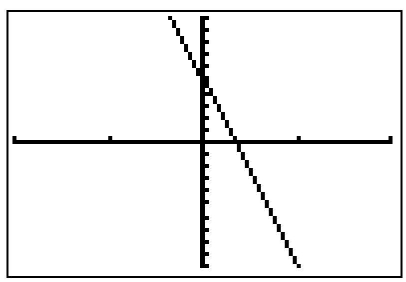
We will solve the equation graphically and determine in what year the Yellow Pages advertising expenditures is equal to $15 billion ($15,000 million). The graph shows that when $t \approx 12$, advertising expenditures is about $15 billion.



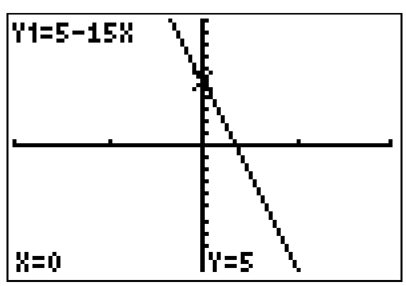
25. The graph shows that the function is decreasing on $(-\infty,\infty)$. The graph shows that the function is concave up on $(-\infty,\infty)$. The y -intercept is (0,2).



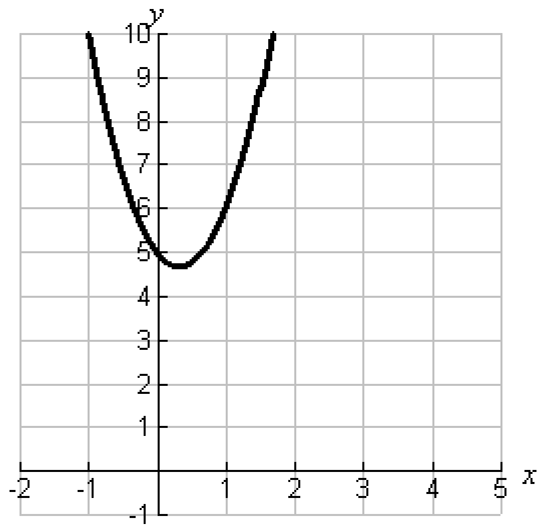
26.



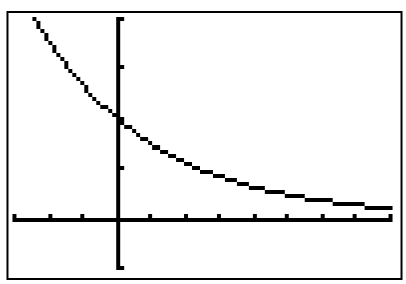
The function is decreasing over the interval $-\infty,\infty$. The function is not concave up or down. The y-intercept is (0,5).



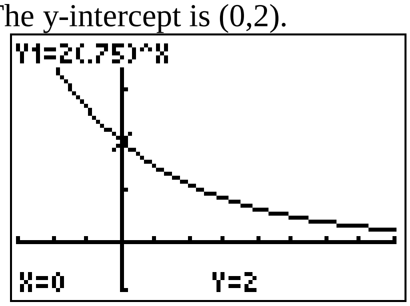
27. The vertex of the parabola is $x = \frac{-b}{2a} = \frac{1}{3}$. Therefore, the function is decreasing on $(-\infty, \frac{1}{3})$. The function is increasing on $(\frac{1}{3}, \infty)$. The graph shows that the function is concave up on $(-\infty, \infty)$. The y-intercept is $(0,5)$.



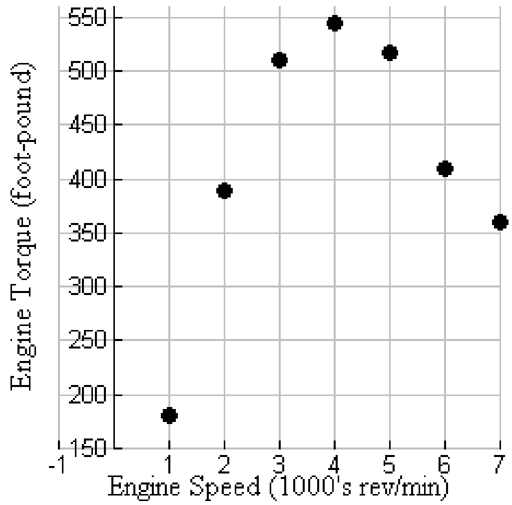
28.



The function is decreasing over the interval $-\infty, \infty$. The function is concave up. The y-intercept is (0,2).



32. a.



b. A quadratic function is most appropriate since the function increases to a maximum and then decreases. There is a changing rate of change so a linear function is not appropriate.

c. $T(s) = -30.38s^2 + 263.9s - 32.43$

d.

$$\begin{aligned} T(5.5) &= -30.38(5.5)^2 + 263.9(5.5) - 32.43 \\ &\approx 500 \end{aligned}$$

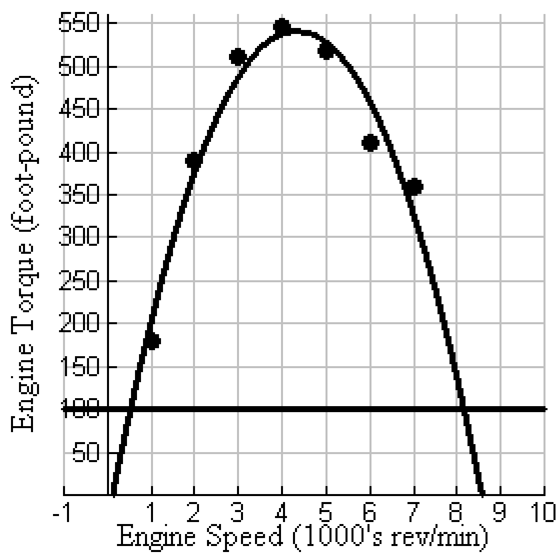
An engine speed of 5500 revolutions per minute will produce engine torque of about 500 foot-pounds.

e. We will use the graph to estimate the solution to the problem.

$$T(s) = T(s) = -30.38s^2 + 263.9s - 32.43$$

$$100 = T(s) = -30.38s^2 + 263.9s - 32.43$$

There are two engine speeds that produce a torque of 100 foot-pounds. From the graph, we estimate them to be s = 0.5 and s = 8.1. That is, an engine speed of 500 revolutions per minute and an engine speed of 8100 revolutions per minute both produce an engine torque of 100 foot-pounds.



f. The vertex or turning point is found by $(\frac{-b}{2a}, f(\frac{-b}{2a}))$.

$$(\frac{-263.9}{2(-30.38)}, f(\frac{-263.9}{2(-30.38)}))$$

$$(4.343, 540.7)$$

This vertex tells us the engine speed the produces the maximum engine torque. This occurs at an engine speed of 4343 revolutions per minute which produces a maximum engine torque of about 541 foot-pounds.

g. $\frac{T(4) - T(2)}{4 - 2} = \frac{537.1 - 373.9}{2} = \frac{163.9}{2} = 81.6$

The average rate of change on the interval [2,4] is 81.6 foot-pounds per revolution per minute. That is, for every increase in engine speed of 1000 revolutions per minute, the engine torque will increase by 81.6 foot-pounds.

h. For the purpose of this exercise, we will find the average rate of change between $s = 4$ and $s = 4.001$.

$$\frac{T(4.001) - T(4)}{4.001 - 4} = \frac{537.116 - 537.095}{0.001} = \frac{0.021}{0.001} = 21$$

We estimate that when the engine speed is 4000 revolutions per minute, the engine torque is changing at a rate of 21 foot-pounds per revolution per minute. That is, when engine speed is 4000 revolutions per minute, an increase of 1 (in thousands) revolution per minute will cause an increase in engine torque of 21 foot-pounds.

33. Let c = price of a candy bar in dollars and t = current year.
$c(t) = 0.60(1.03)^t$

34. Let p = price of a home in Queen Creek, AZ in thousands of dollars and d = number of days since March 12th, 2004. We know that

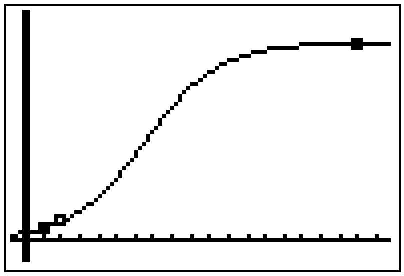
d	p
0	198.9
4	205.9
18	209.9
32	212.9

No function fits the data really well but linear is a relatively good model so $p(d) = 0.381d + 201.755$

36. $M(t) = 95(0.96)t$

37. The mathematical model for forecasting the monthly product sales should be logistic because we are told “sales will be initially slow but will increase rapidly” and “sales will start to level off”. We create a table of data and then a scatterplot and find the logistic regression.

Year y	Sales S
1	12000
2	19000
18	200000



$$S(y)=\frac{200669.40}{1+25.85e^{-0.50y}}$$

47. a. $BP(w)=\frac{2}{5}w+49$

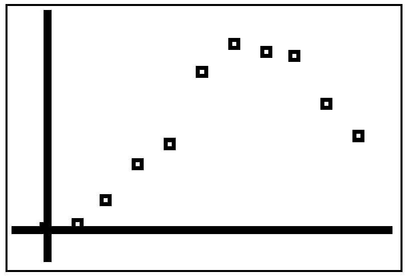
b. The slope indicates that if the person's blood pressure increases by 2 millimeters of mercury, his weight increased by 5 pounds.

c. The vertical intercept is (0,49). In the context of the situation, this says that a person who weighs 0 pounds would have a systolic blood pressure of 49 millimeters of mercury. This vertical intercept is not part of the practical domain since there is no such thing as a 35-year-old male who weights 0 pounds.

48 a. We can't tell which function to choose simply from the differences and ratios because none of them appear to be constant.

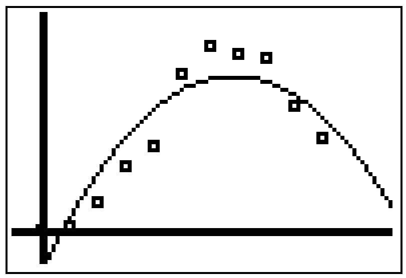
Year y	United States Per Capita Cigarette Consumption S	Δc	$\Delta(\Delta c)$	$\frac{c_{i+1}}{c_i}$
00	54			
10	151	97		2.796
20	665	514	417	4.404
30	1485	820	306	2.233
40	1976	491	-329	1.331
50	3552	1576	1085	1.798
60	4171	619	-957	1.174
70	3985	-186	-805	0.955
80	3851	-134	52	0.966
90	2827	-1024	-890	0.734
100	2092	-735	289	0.740

We now look at the scatterplot and see that the cigarette consumption is increasing at first but then decreases.



The most reasonable choice would appear to be quadratic since quadratics can increase and then decrease when they are concave down. Linear and Exponential functions will either always increase or always decrease.

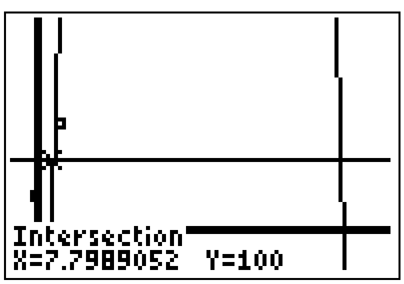
b. The quadratic function that best models these data is
$c(y) = -0.91y^2 + 125.27y - 821.62$

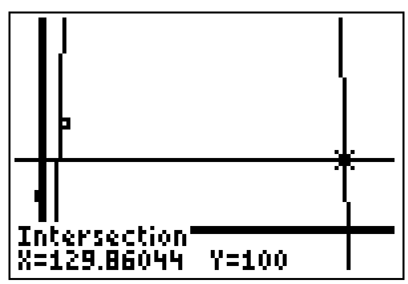


c.
$$c(100) = -0.91(100)^2 + 125.27(100) - 821.62$$
$$\approx 2605$$

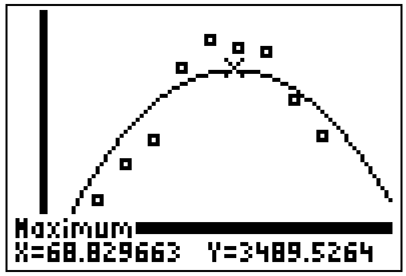
In 2000 the estimated per capita cigarette consumption is 2605 per person.

d. Solving $100 = -0.91y^2 + 125.27y - 821.62$ by graphing gives us approximately years 8 and 130. This would mean in 1908 and 2030 the per capita cigarette consumption would be only 100 per person.





e. In approximately in year 69 (1969) the cigarette consumption reached a maximum of 3489 per person. (Note that this is lower than the actual number as displayed in the scatterplot for the year 1969. This is because the function c(y) is a mathematical model used to estimate the solution.)



f. $\dfrac{3166-2733}{50-40} = 43.3\dfrac{\text{cigarettes}}{\text{year}}$ This means that the number of cigarettes consumed per person from 1940 to 1950 increased an average of 43 each year. This would seem reasonable because in the 40s people were smoking more and more.

g. $\dfrac{3081-3375}{90-80} = -29.4\dfrac{\text{cigarettes}}{\text{year}}$ This means that the number of cigarettes consumed per person from 1980 to 1990 decreased an average of 29 each year. This would seem reasonable because in the 80s people were smoking less due to the anti-smoking campaign.

h. $\dfrac{2866-2913}{95-94} = -47\dfrac{\text{cigarettes}}{\text{year}}$ This means that the number of cigarettes consumed per person in 1995 was decreasing by about 47 each year. This would seem reasonable because people are smoking less due to health concerns, etc.